Denali National Park & Preserve

Soundscape Annual Report 2004

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Note: Being that this is the first Annual Report for the Soundscape Studies done at Denali National Park and Preserve this report will include summaries of previous work accomplished.

INTRODUCTION

The ever-increasing human-generated sounds at Denali National Park and Preserve have become an important resource issue because of their detrimental impact on the natural soundscape and visitor experience. The Denali National Park and Preserve Backcountry Management Plan (BCMP) is currently being revised, with a completion date set for spring 2005. In the BCMP soundscape measurements have been identified as an important indicator of the level of human impact on park resources. Soundscape measurements are objective with the methods easily reviewed by the public, which will provide strong support for future management decisions. Park planners have increasingly expressed a desire for more soundscape data so that he can make informed decisions about the sound level standards that will be set in the BCMP. Without these data the park will have little information to make management guidelines or support management decisions that may affect the quality of the Park's soundscape.

The impetus behind the Denali National Park and Preserve Soundscape Studies has been to measure the level of impact from overflight traffic and snowmachine traffic. Denali National Park and Preserve has been developing soundscape monitoring techniques and applications since 2000. The Soundscape studies have been funded through two primary projects: the "Southside Development Study" (PMIS DENA 24759; and the "Toklat Basin Ecological Study" (PMIS DENA 24779; the history of Denali National Park & Preserve soundscape program funds, personnel, reports, and presentations are outlined in Appendixes A and B). These studies have primarily been aimed at finding an effective way to develop baseline information that will allow management to protect sound resources. As of December 2004, park staff have collected sound level data and digital recordings at 16 locations throughout the park (Fig. 1). The extent at which stations occupied each location are represented in the charts in Figures 2 and 3. Generalizing from a subsample of sound level data several sound sources are common to all three acoustical zones including the natural sounds of wind, snowfall, rain, flowing water, thunder, migrating birds and ravens. Also, the presence of human-generated sounds such as aircraft and surface vehicles depends of the proximity to a travel corridor.

The initial push for Denali National Park & Preserve to begin soundscape inventories began with Director's Order 47. Robert Stanton issued Director's Order 47 in 2000 directing park managers to identify baseline soundscapes and related measures. DO-47 states that "natural sounds are intrinsic elements of the environment that are often associated with parks and park purposes…They are inherent components of 'the scenery and the natural and historic objects and the wild life' protected by the NPS Organic Act." DO-47 directed park managers to "(1) measure baseline acoustic conditions, (2) determine which existing or proposed human-made sounds are consistent with park purposes, (3) set acoustic management goals and objectives based on those purposes, and (4) determine which noise sources are impacting the park and need to be addressed by management." Furthermore, it requires park managers to "(1) evaluate and address self-generated noise, and (2) constructively engage with those responsible for other noise sources that impact parks to explore what can be done to better protect parks."

Understanding the natural soundscape is important to evaluate the levels of impacts human-generated sounds may have on this important resource. The natural soundscape is generally comprised of two main sound categories, biophony and geophony. Biophony is all sound created by organisms (birds, frogs, plants, etc.) and geophony is all sound created by physical forces (wind, rock fall, rivers, etc.). The sounds from these two categories can be used to characterize different habitats. Different Habitats have specific soundscape characteristics that are an important attribute of the natural system, with distinct impacts on the human perception of the environment. Impacts on the natural soundscape and on visitor experiences come from human-generated sounds.

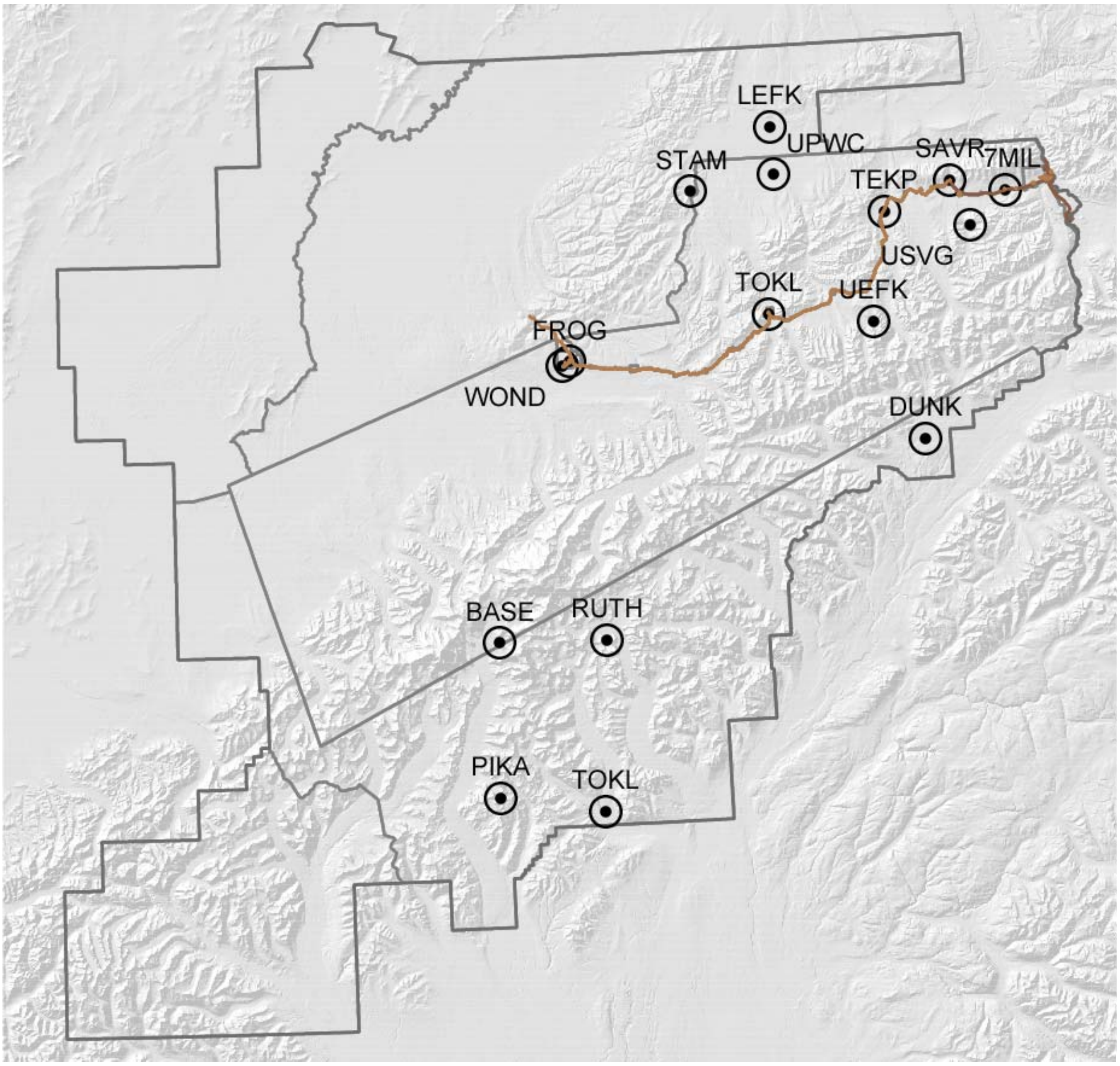

Figure 1. Map showing the sound station locations placed from 2001-2004.

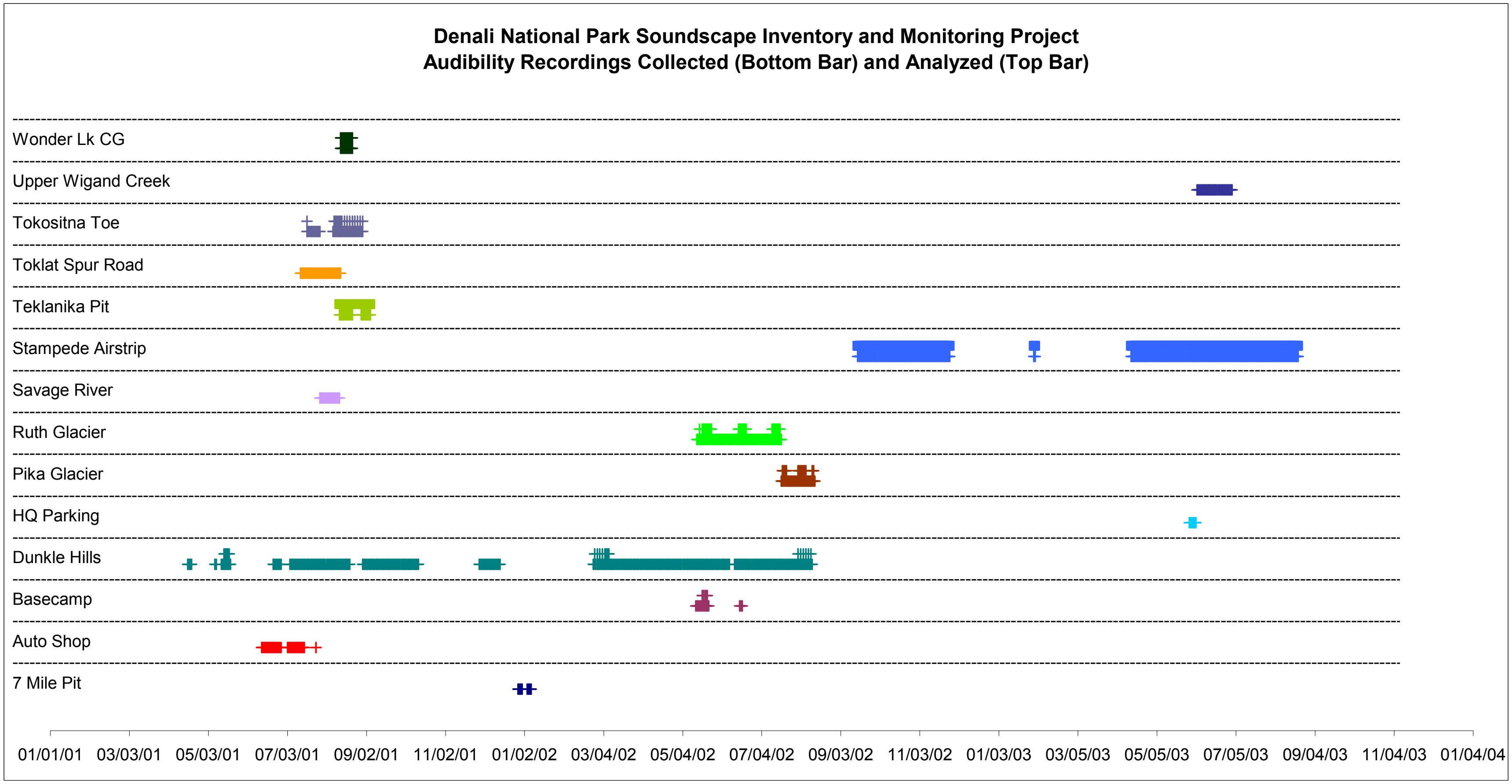

Figure 2. Chart showing the periods of time that a sound station occupied the various locations shown in Figure 1. The lower points for each location are the days that data was collected. The upper points represent the days that have been analyzed.

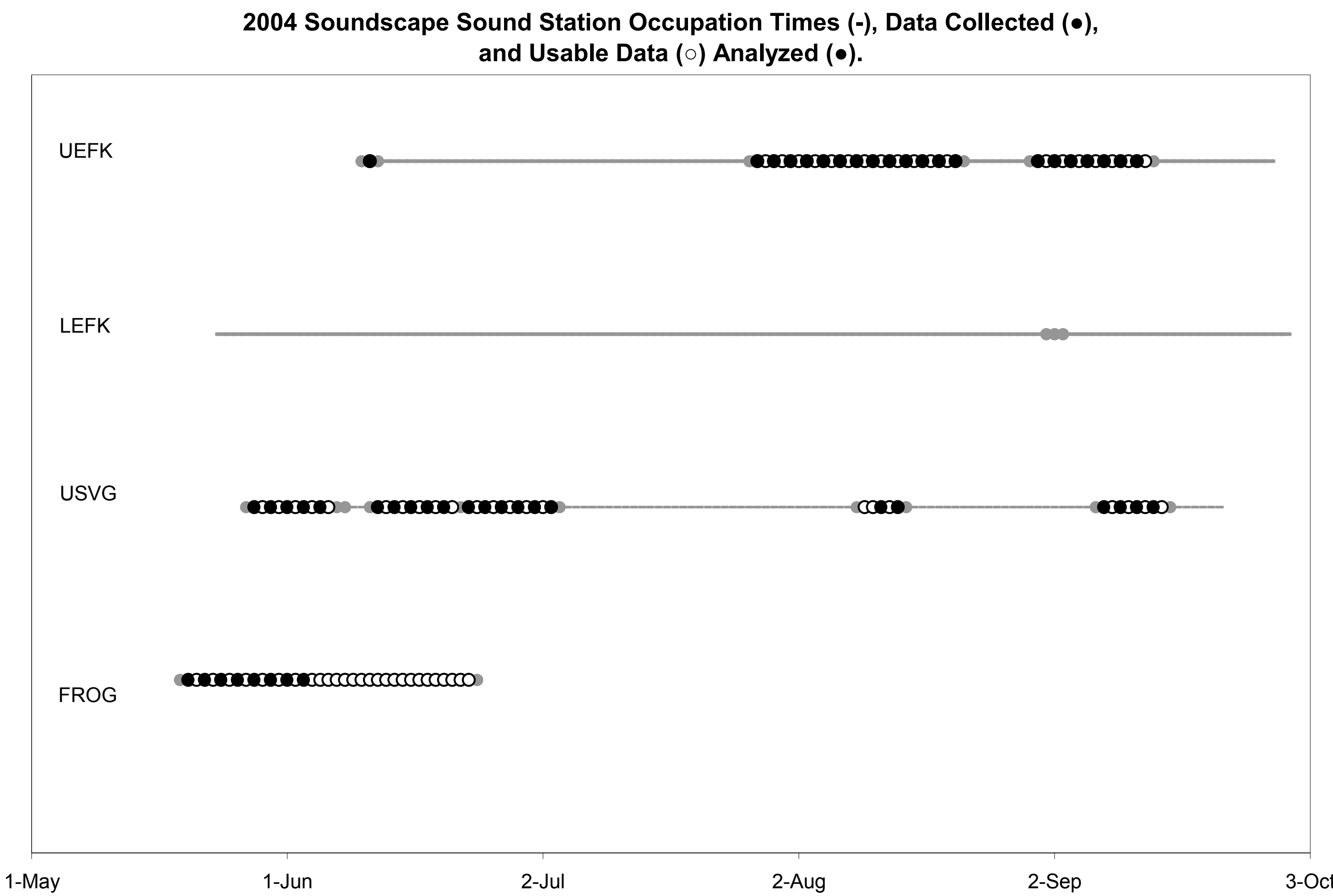

Figure 3. Chart showing the 2004 sound station occupation times, data collected, and usable data analyzed, as of Nov.10, 2004 (for station locations refer to map in Figure 1).

DATA COLLECTION

Equipment used

Denali National Park and Preserve, in full coordination with the national program, is at the forefront of sound study design service-wide. Denali National Park and Preserve has been developing soundscape inventorying methods since 2001. Automated acoustic data loggers, designed by Skip Ambrose at the NPS Natural Soundscape Program Center, collect one-second decibel data as well as digital recordings using a systematic sampling scheme (5 seconds every 5 minutes), and 10second recordings of sound events exceeding a user-defined threshold (usually 55dBA) and duration (usually 5seconds). Calibrated Type 1 *Larson-Davis Model 824* sound level meters, Type 1 *Larson-Davis PRM902* microphone preamplifiers, and Type 1 *G.R.A.S. 40AE* microphones, with windscreens, are used to collect 33 one-third octave band frequency (12.4-20,000Hz) sound pressure levels each second of the sampling period. Sound monitor™ (Far North Aquatics, Fairbanks, Alaska) software, running on a Windows™ - based Panasonic™ CF-45 laptop computer, control and store the acoustical data. Each system collects CD quality digital recordings (44.1KHz, 16-bit) using an external sound card. The acoustic data loggers, contained within weatherproof containers, are powered by 12volt battery and photovoltaic charging systems. The system can operate continuously for long time periods, provided that there is enough sunshine.

Specific methodologies and protocols for equipment type, microphone type, microphone placement and height, and other factors are followed as described in the guidelines in the Draft Reference Manual 47. These protocols were developed following guidance of Ambrose and Burson (2004) and were based on American National Standard Institute S12.9 (1992), Federal Aviation Administration's "Draft Guidelines for the Measurement and Assessment of Low-level Ambient Noise" (Fleming et al. 1998), and "Methodology for the Measurement and Analysis of Aircraft Sound Levels within National Parks" (Dunholter et al. 1989).

The equipment used for monitoring the soundscape is shown in Figures 4 and 5. Detailed equipment lists used at each location sampled can be found in Appendix C. The equipment is described below:

- **Data Logger (Laptop).**
  - *Panasonic Toughbook* running *Windows 2000* or greater and using *SoundMonitor* software developed by *Far North Aquatics*, Fairbanks, AK.
- **Sound Level Meter (SLM) and Microphone**
  - *Larson-Davis 824* Type 1 Sound Level Meter (SLM). Type 1 microphone and preamp with both a *Larson-Davis* foam and *Rycote* (fuzzy) windscreen.
- **High Quality Digital Sound Card and Omnidirectional Microphone**
  - *M-Audio MobilePre* USB powered external sound card with 48V Phantom microphone power for a *Sennheiser ME 62* omnidirectional microphone.

- **Power Supply**
  - At the high latitudes of Denali with the system currently used (1.0 Amps), a minimum of 160 Watts of solar panels are necessary for summertime applications. Wintertime applications require up to 2000Watts of solar panels.
  - 140 Amp hours worth of deep cycle batteries are generally sufficient for retaining enough power during summertime applications. The battery power must be ample enough to last between solar charges that may be insufficient for weeks at a time due to poor weather.

The equipment is secured in a way that there is no self induced noise (e.g., from loose wires). The equipment is protected from animal mischief through the use of conduit, strong cases for the digital equipment, and in some cases, using an electric fence. Extensive protocol instructions developed by the National Park Service Soundscapes Program Center for using the equipment to measure soundscapes in national parks are explained in Reference Manual 47.

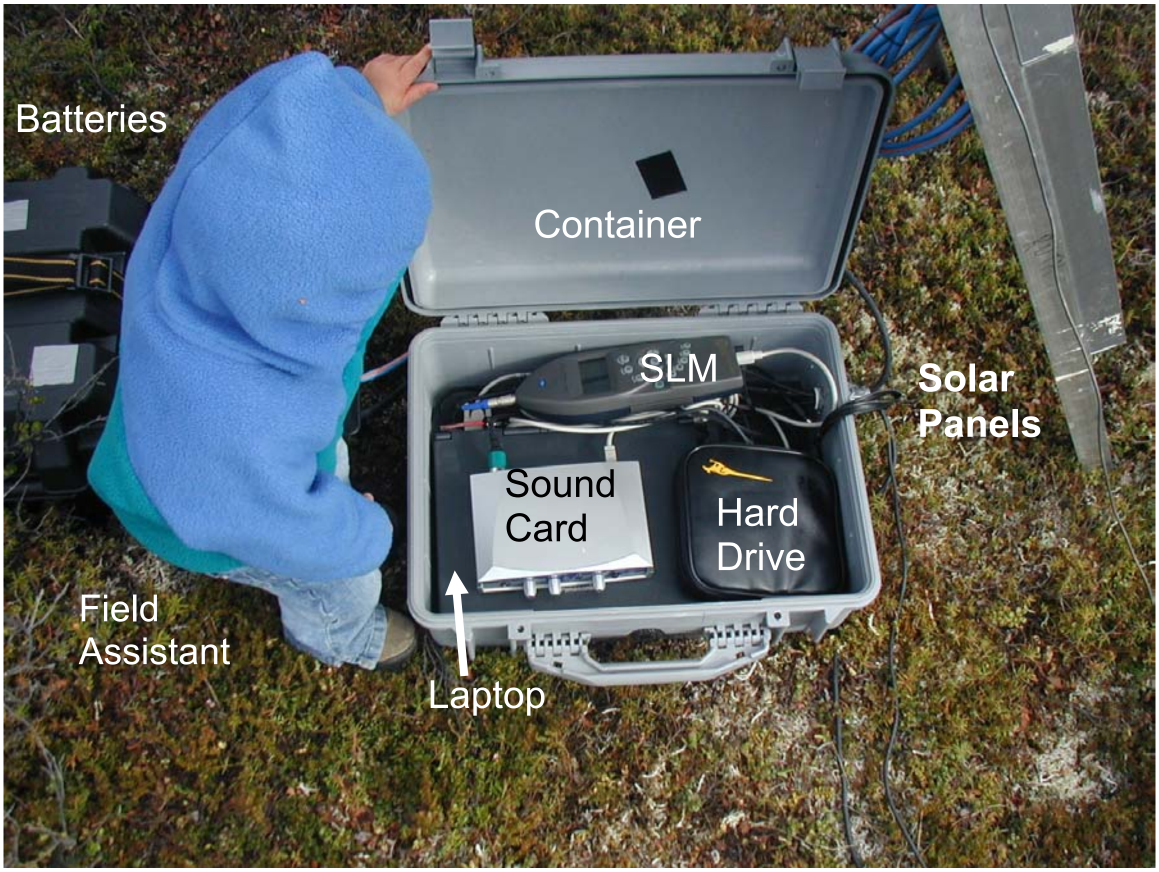

Figure 4. Photograph of the inner workings of a sound station. Sound stations run off solar panels and batteries. They contain a laptop, external sound card, external hard drive, and a sound level meter, which are all contained in a *Pelican* Case.

Figure 5. Photograph of the microphones used for audio recordings and measuring sound pressure levels.

Data collected

Two types of data are collected at a sound station: audio recordings and sound pressure levels. Two types of audio recordings are made; one type at user defined time intervals and the other triggered at user defined sound levels. Sound pressure levels are taken every second. The data collected are:

- **Events** are audio recordings that are triggered by loud sounds at user defined exceedance levels. The user defined exceedance levels traditionally used at Denali have been sounds greater than 55dBA for 5 or 10 seconds and 90dBAfor one second. An audio recording of an event is made during the event for 5 seconds before and after the event.

- **Audibility Audio Recordings** are made at user defined intervals. Traditionally, at Denali National Park and Preserve, audio clips recorded for 5 seconds every 5 minutes have been sufficient for identifying sound sources. This data is used to calculate the percent time and number of times sound sources are audible throughout the day.

- **Sound Levels** are taken every second. Recorded are the overall A-weighted Leq, and the Flat Weighted Leq of each third octave. Leq is the energy equivalent sound level which is the level of a constant sound over a specific time period that has the same sound energy as the actual (unsteady) sound over the same period. The A-weighted sound pressure level (dBA) is weighted based on limits of human hearing.

The locations in Figure 1 were chosen to support the project goals as listed in Apendix A. The focus of the soundscape study in 2004 was divided between two priorities, based on funding sources (see Appendix A) they were; to collect data from the Old Park for support of the BCMP, and to collect data from the Toklat Basin. To accomplish these goals three sound stations were placed in the Old Park (FROG, USVG, and UEFK, in Figures 1, 2 and 3), and one station was placed in the Toklat Basin (UEFK in Figures 1, 2 and 3). The following is a summary of the station data collection successes and issues.

The time periods sound stations were in place during 2004, and the amounts of usable data collected are shown in Figure 3. There were four stations placed during the 2004 field season:

FROG - Located at a frog pond along the Wonder Lake Campground road,
USVG - Located in the Upper Savage River Valley at an LTEM grid point
UEFK - Located in the Upper East Fork River Valley 4mi south of Sable Pass
LEFK - Located along the East Fork River north of the Lower East Fork Cabin.

The purpose of the FROG sound station location was to collect data from within the Old Park and at a location where we could capture the Wood Frog breeding season. The station was placed as soon as the road was open to administration traffic and removed a month latter. The data will be analyzed for both the audibility of all sound sources and particularly for the abundance of frog calls. A relative abundance scale commonly used for audio frog call counts will be used when analyzing the data; 1 - frog calls with space in between, 2 - frog calls with no breaks between calls, 3 - frog calls that overlap each other with no space between calls. The data will be correlated with the research done by Grant Hokit who is a visiting researcher from the University of Montana doing an extensive frog survey of the Wonder Lake area.

The purpose of the USVG and UEFK locations were to collect data from within the Old Park away from the road and under the popular north side flight paths. The data collected up until 2004 was primarily from the New Park Additions and along the park road. Until 2004 the popular hiking area in the Old Park had not been studied. The USVG station was placed at the LTEM grid point that Carol MacIntyre and her bird crew did a bird survey. The recordings from the USVG and FROG stations are currently being analyzed by Carol MacIntyre and consultants.

The purpose of the LEFK location was to collect more data from the Toklat Basin in order to fulfill the soundscape portion of the Toklat Basin Ecological Study. The station was long-lined from the STAM location to the LEFK location (Fig. 1) during the first part of the season. The station did not produce any useful data because of a bad battery that was not detected till the latter part of the summer. Detection of the bad battery was hampered by three hurdles; 1) since the station was only accessible by helicopter the station could only be accessed once a month, 2) the battery voltage level was always high because of a fresh charge from the solar panels since the laptop was not running before the visits, 3) I had not ever experienced the symptoms of a dead battery. The symptom noticed was that the sound station would only work for a few hours after a site visit. The symptom was first assumed to be related to the solar controller so the power connections were rewired. The solar controller rewiring did not fix the problem. The possibility of a bad battery was figured only after discussing the situation with Pam Sousanes, the weather station guru. The last site visit during September I unplugged the solar panels from the batteries and from each other. This allowed them to discharge individually. There were two batteries that discharged significantly after only an hour. I had brought new batteries and replaced all of them except for the one that held its charge the best. The station was running when it was checked three days after replacement of the batteries.

The success rate of all the sound stations was low; data was collected for only 30% of the days that the sound stations were placed (Fig. 3). The best result was from the station placed at frog ponds near the Wonder Lake Campground (FROG), which obtained useful data for every day the site was occupied (100% success). The second best success rate was from the Upper Savage sound station at 45%. The Upper East Fork sound station (UEFK) had a success rate of 41%. The worst success rate was at the Lower East Fork sound station (LEFK) which did not work for any of the days during the 2004 field season.

The problems with the UEFK and USVG stations were a combination of inaccurately calculated system amperage compounded by many days of smoke, which reduced the power input by the solar panels. The system amperage was initially calculated using a clamp meter on the power line input to the sound station and amperages were taken every five seconds for five minutes. The result was an estimate of an overall power drain of 0.73 amps. The power needs were then calculated using the average minimum solar input for Denali. The power needs were estimated to need a minimum of 120W of solar power and 100Ah worth of battery power. The stations did not perform as desired with these specifications during the 2005 season, so, during the middle part of the summer more solar panels and an additional 35ah battery was brought to both stations. This increase in power made the stations more reliable. Later in the season, an inline Amp/Watt/Ah meter was purchased and used to test the power drain of the sound station system. The new meter calculated the power draw to be nearer to 1.0A instead of the previously calculated 0.73 amps. The resulting minimum power needs for the summer season in Denali area were then estimated to be 160W PV and 140Ah of batteries. Note that the minimum solar panel wattage needed to run a 1.0A system in the Denali area during December and January is 2000W. With more power at the stations, the 2005 should see a higher success rate.

DATA ANALYSIS

Data is dead until it is analyzed and displayed in a way that is useful. The soundscape data collected has to be analyzed and displayed in a way that is useful for park managers. To refine the large volume of data collected the audio recordings first had to be analyzed, then custom automated programs had to be developed that could compile and compute the audibility and sound level data.

The days for which the audio recordings were analyzed, thus far, are shown in Figures 2 and 3. To analyze the systematic audio recordings the playback has to first be calibrated so that the loudness of the sounds played through the headphones is equivalent to what a person would hear at the site. To do this, the microphone calibrator is played into the microphone and recorded during every site visit. The calibrator recording is then played back through the headphones prior to listening to the audio recordings. A *Larson-Davis 824* sound level meter is used to measure the sound level of playback of the calibrator through the headphones. The microphone of the sound level meter is placed in one of the headphone pieces and the playback volume is adjusted to match the calibrator volume. Studies have shown that sounds played back through headphones are 7dBA less audible than the same sounds played back in free air (ANSI, 1968). Studies have also shown that sounds played back in monotone are 3dBA less audible than when played back in stereo (ANSI, 1968). To correct for these playback deficiencies the playback volume is increased 10dBA greater than the calibrator volume. Calibration of the playback volume increases the accuracy of the calculation of the audibility of sounds heard at each site. Tests done by the National Park Service Soundscape Program Center have shown that this method of calculating audibility is consistent with data collected by attended logging done in the field.

After the audio recordings are analyzed the data then needs to be compiled, combined with the sound level data, and displayed in a way that is useful for park managers. Before 2004 there had been no processes or programs designed for efficient data analysis. The programs had to be designed. Three custom Excel macros designed to compile, combine, and display the data, were programmed by me using Visual Basic. These Macros are listed and described below:

SPL Macro-This macro converts the sound pressure level data from text files to Excel files and displays each hour's one second sound pressure data in a chart.

SLP & Audibility Compile Macro – This macro combines the sound pressure level data and the audibility analysis data together and calculates the sound levels for each of the 288 five second segments. The output is an Excel file.

Data extraction and Display Macro – This macro extracts the pertinent data from the files created above and displays the data in various charts that summarize the data in a way that is useful for Park planners.

A summary of the results of all the data analyzed as of December 2004 can be found in Appendix D.

BACKCOUNTRY MANAGEMENT PLANNING

Soundscape standards will be a major component in the revised draft Denali Backcountry Management Plan (BCMP) that will be published fall 2004. In the draft BCMP desired soundscape standards will be set for various zones in the park (see the zones map in Figure 6. The soundscape standards were defined through correspondence with the National Park Service Soundscape Program Center, discussions during BCMP impact planning workshops held by the planning team at Denali, and through discussions about the effects of each alternative with Joe VanHorn, Guy Adema, Chad Hults, and Charlie Loeb. The soundscape disturbance level zone standards agreed upon through the communications above are shown in Table 1, which describe the desired soundscape conditions by setting limits on the following:

- Percent time of each hour motorized sounds are audible.
- Number of times per day motorized sounds are noticeable above the natural ambient sound level.
- Maximum motorized sound levels.

The motorized component of the data in Appendix D will be published in the Revised Draft Denali Backcountry Management Plan (BCMP) in fall 2004. The motorized sounds components in Appendix D will be useful for comparing BCMP standards set in Table 1 to the actual conditions found throughout the park. For example, bar charts showing a compilation of motorized impact levels for the Stampede Airstrip during the month of June (STAM in Fig. 1) are shown in Figures 7, 8, and 9. In the preferred alternative in the draft BCMP, the Stampede Airstrip location is located in a medium soundscape disturbance level zone (Unit 40 in Fig. 6). The desired conditions for a medium soundscape disturbance level (see Table 1) are: motorized sounds should not be audible more than 15% of each hour; there should be no more than ten motorized sounds per day greater than natural ambient; and motorized sounds should be less than 40dBA. Compare these standards to the bar charts in Figures 7, 8, and 9. Figure 7 shows the number of hours in the month that exceeded selected intervals for the percent time motorized sounds were audible per hour. From this chart we can see that fourteen hours of the month exceeded the desired condition set at 15% of each hour for the Stampede area. Figure 8 shows the number of motorized sounds that were in-between selected A-weighed decibel levels for the month. From this chart we can see that twenty three motorized sounds audible during the month were above the desired limit set at 40dBA. Figure 9 shows the number of motorized sound levels, per day, that were above the natural ambient sound level. From this chart we can see that there were no days during the month that exceeded the desired level set at no more than ten motorized sound levels per day greater than natural ambient. Comparisons like these can be made for every location that data summaries are provided for in Appendix D.

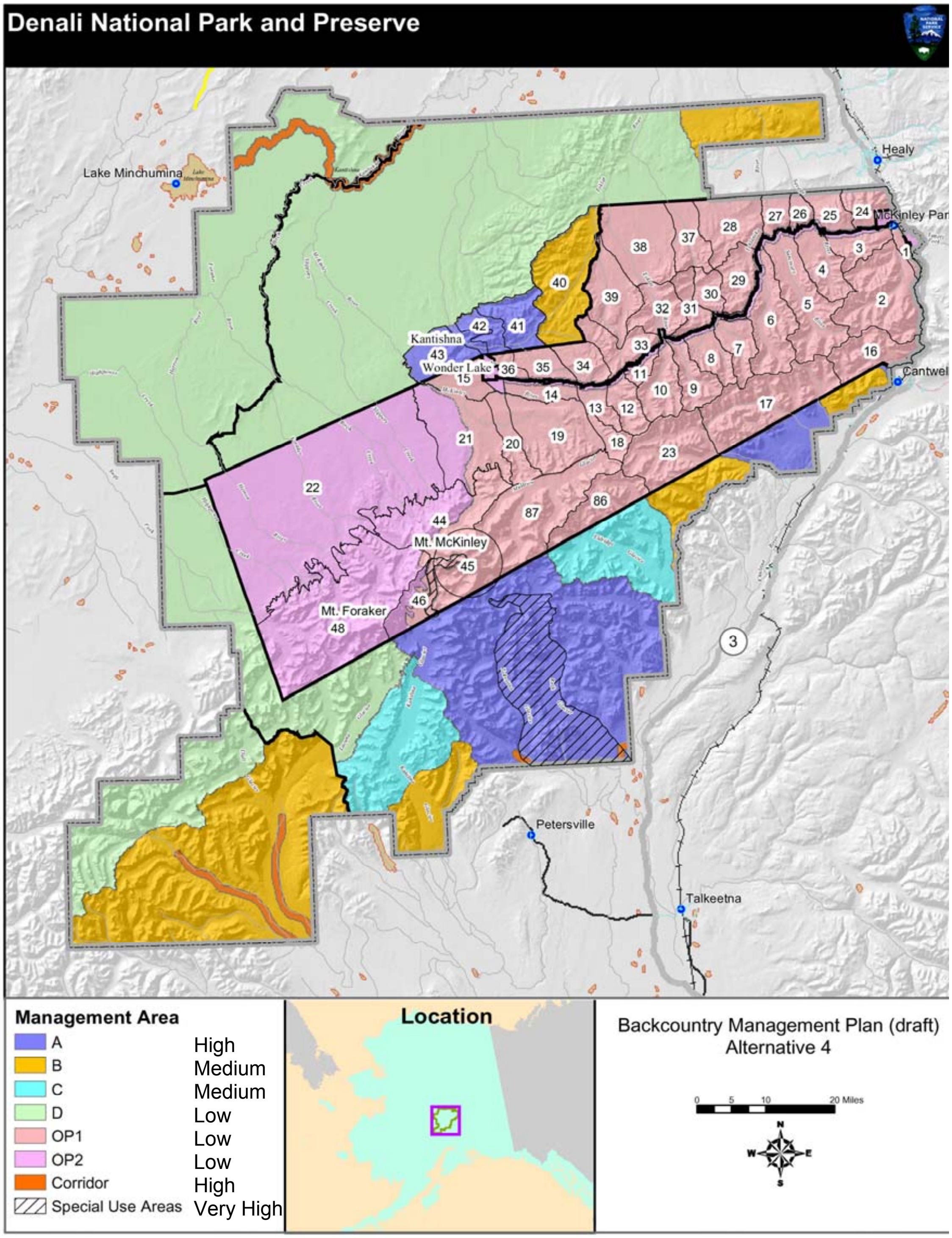

Figure 6. Map of the management zones and desired motorized sound impact levels, as defined in the preferred alternative in the draft BCMP (Loeb, Personal Communication).

Table 1. Indicators and standards for each soundscape disturbance level zone (Fig. 17), as defined in the revised draft BCMP (Loeb, Personal Communication).

<table>
<tr><th colspan="4">Natural Sound Disturbance</th></tr>
<tr><th>Descriptor</th><th>Description</th><th>Monitoring</th><th>Process for Adjustment</th></tr>
<tr><td>Very High</td><td>Natural sounds are often interrupted by motorized noise including loud noise. Motorized noise may be audible up to 50% of any hour, and there may be up to 50 motorized noise intrusions per day that exceed natural ambient. Motorized noise would not exceed 60dBA at 50 feet.</td><td rowspan="4">Sound monitoring would be conducted on a continuous basis using remote monitors. Long-term monitoring and attended monitoring would take place at locations of particular concern or where it has been determined that management action is necessary to meet standards. Other locations would be randomly sampled.</td><td rowspan="4">Indicators and standards would be used as benchmarks for five years while additional information is gathered through the initial stages of the monitoring program. After five years, the NPS would propose changes to either the indicators or standards through a public process. Relative differences between categories (Low, Medium, High, Very High) would be retained during the revision process.</td></tr>
<tr><td>High</td><td>Natural sounds are frequently interrupted by motorized noise including some loud noise. Motorized noise may be audible up to 25% of any hour, and there may be as many as 25 motorized noise intrusions per day that exceed natural ambient. Motorized noise would not exceed 60dBA at 50 feet.</td></tr>
<tr><td>Medium</td><td>Natural sounds predominate in this area, but there will be infrequent motorized intrusions, a few of which may be loud. Motorized noise may be audible up to 15% of any hour, and there may be as many as 10 motorized noise intrusions per day that exceed natural ambient. Motorized noise would not exceed 40dBA at 50 feet.</td></tr>
<tr><td>Low</td><td>Natural sounds predominate in this area and motorized noise intrusions are very rare and usually faint. Motorized noise may be audible up to 5% of any hour, and there will be no more than 1 motorized intrusion each day that exceed natural ambient. Motorized noise would not exceed 40dBA at 50 feet.</td></tr>
<tr><td colspan="4">Notes: “Audible” means audibility to a person of normal hearing. Natural ambient is calculated as the median sound pressure level (L_{50}) when no motorized sounds are present.</td></tr>
</table>

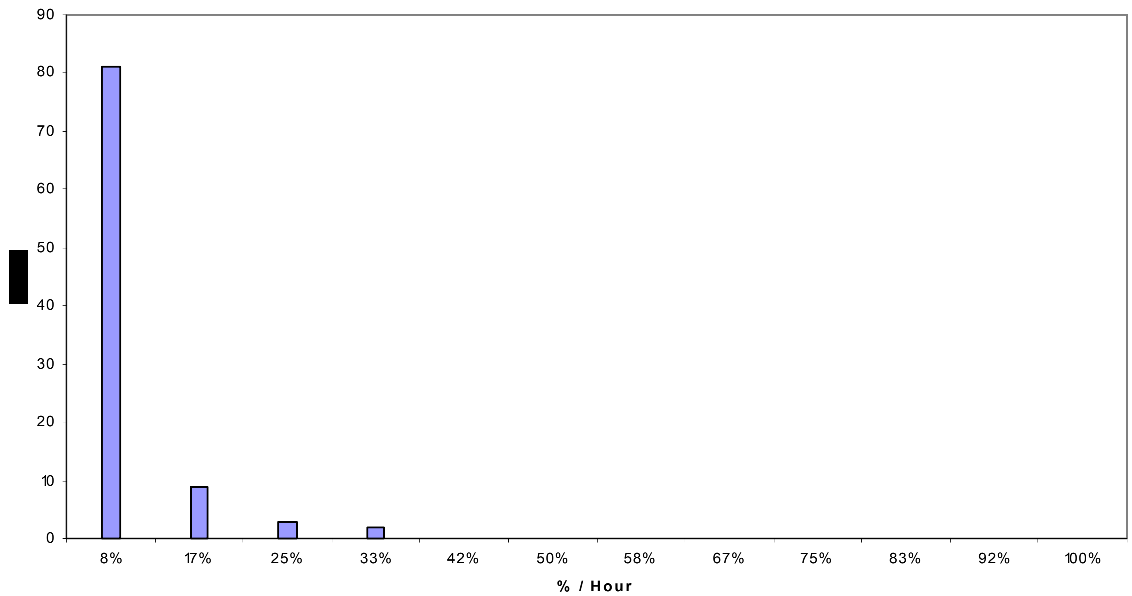

Figure 7. Chart showing the number of hours in the month of June that exceeded selected intervals for the percent time motorized sounds were audible per hour. Data is from the Stampede Airstrip (STAM in Figure 3).

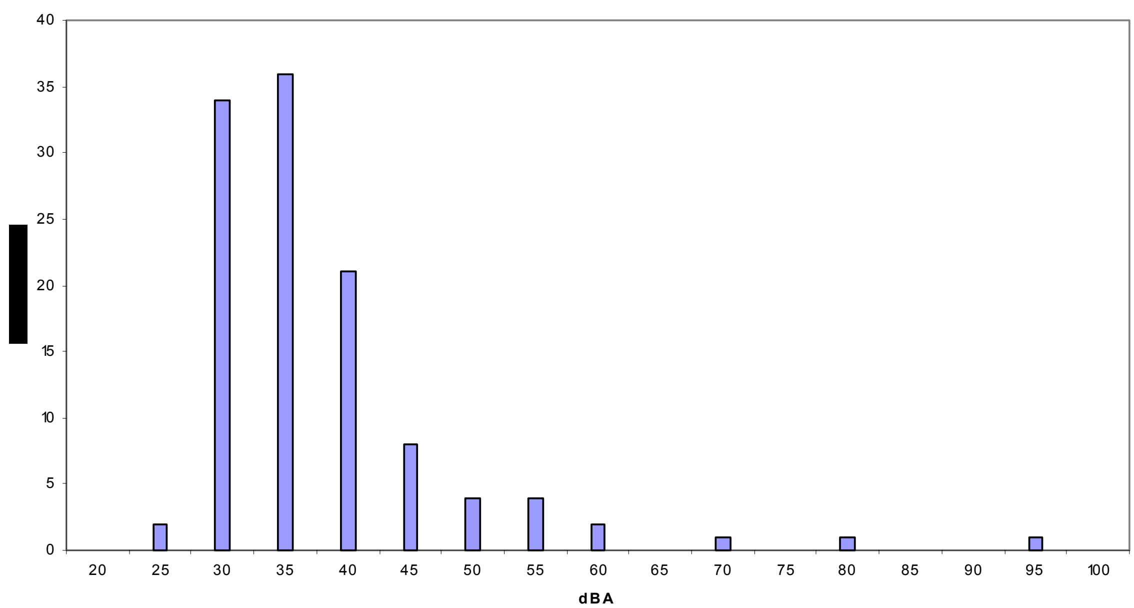

Figure 8. Chart showing the number of motorized sounds that were in-between selected A-weighted decibel levels for the month of June 2003 at the Stampede Airstrip (STAM in Figure 3).

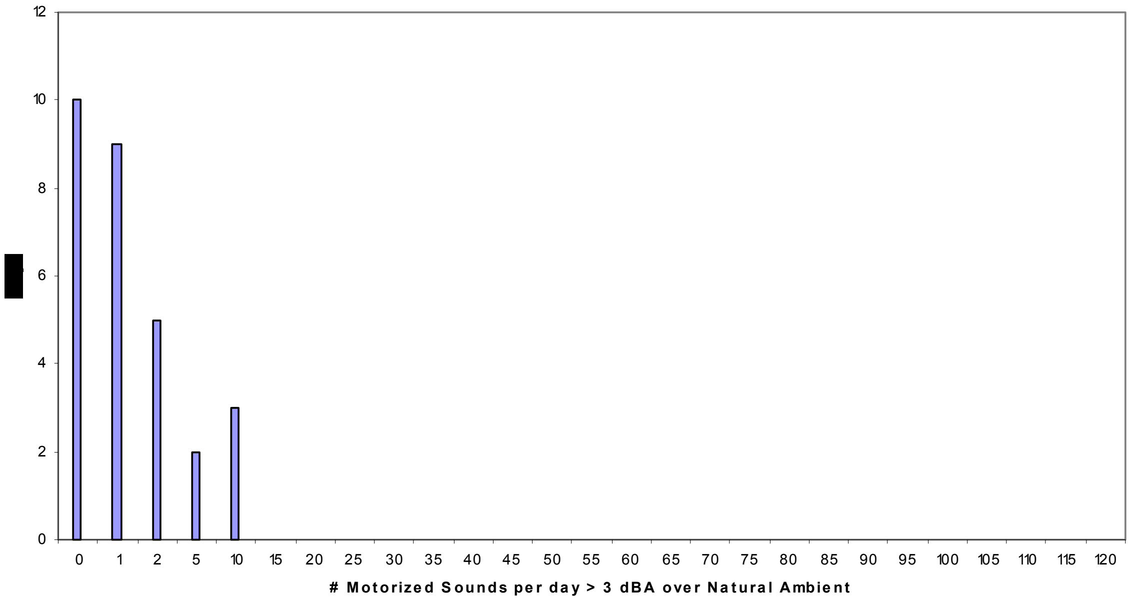

Figure 9. Chart showing the number of motorized sound levels, per day, that were above the natural ambient sound level. Data are from the month of June 2003 at the Stampede Airstrip (STAM in Figure 3).

CENTRAL ALASKA NETWORK PLANNING

The Central Alaska Network (CAKN) is interested in utilizing soundscape monitoring as a vital sign for long-term monitoring. The network includes Wrangell-St. Elias, Yukon-Charley Rivers and Denali National Parks and Preserves. CAKN requested that a there be a soundscape scoping meeting in 2004 to discuss the usefulness of including soundscape monitoring in the Inventorying and Monitoring program. CAKN requested background research be done to summarize the techniques that would be useful for long-term monitoring of the soundscape. The background research was done and the meeting was held on November 29, 2004. The outcome of the research is summarized in the Pre-CAKN Soundscape Scoping Meeting Report. The outcome of the meeting is described in the post-meeting results outline sent to all participants. A summary of both is briefly described below.

The background research was focused on summarizing all the ways that soundscape data could be used for long-term ecological monitoring. Three techniques were identified as useful tools for characterizing the natural soundscape: sound level averages, frequency levels averages, and audibility abundances. These tools are described in detail in the Pre-CAKN Soundscape Scoping Meeting Report. The meeting was attended by the following people from CAKN:

Attendees

Yukon-Charley

David Mills, Superintendent (Attended Morning Presentations)
Tom Liebscher, Chief of Natural Resources

WRANGELL

Devi Sharp, Chief of Natural Resources
Eric Veach, Fisheries Biologist
Carol McIntyre, Ornithologist (Attended Afternoon Discussion)

DENALI

Guy Adema, Physical Scientist
Philip Hooge, Assistant Superintendent for Resources, Science, and Learning
Chad Hults, Physical Scientist, Meeting Organizer and Soundscape Project Specialist
Larissa Yokum, Physical Scientist, Notes taker
Charlie Loeb, Denali Planning

OTHERS

Shan Burson, Ecologist-Soundscape Program Manager at Grand Teton; Denali Ecologist and Soundscape Program Manager 2000-2003

Chris Hobbs, Sound Engineer, Wyle Acoustic Group, Wyle Labs, Arlington Virginia.
Karen Oakley, Biologist, Alaska Science Center, U.S. Geological Survey
Diane Sanzone, Arctic Alaska Inventory and Monitoring Network Coordinator
Doug Wilder, CAKN Data Manager
April Crosby, Meeting Facilitator

The meeting was successful in that we were able to identify the issues for each park, identify the priority level of soundscape monitoring in the CAKN, and recognize the steps that need to be completed before soundscape monitoring in CAKN can be realized. All parks expressed interest in having soundscape studies done in their parks. All parks recognized overflight traffic as the major issue that could be managed using soundscape data, as well as minor issues such as boat and snowmachine traffic. All parks were also interested in characterizing the soundscapes of the parks since there is little or no data in some parks. Parks were also interested in the ecological information that could be extracted from the soundscape data, although this information would not be the primary goal of a soundscape program in CAKN. The sample design and scope was discussed and a stratified random sampling design was agreed upon. This design would provide the most statistically valid information for the least cost, although what the design should be stratified by was not agreed upon. More discussion about where soundscapes fit into CAKN will be held with the CAKN technical committee.

TOKLAT BASIN STUDY

Three locations have been occupied within the Toklat Basin; Stampede, Wigand Creek, and Lower East Fork (See Fig. 1). The Stampede location was occupied from 9/2002 to 9/2003. During two periods we were not successful at collecting data. The winter months from Dec-Feb are too dark to keep an adequate charge in the batteries. As a result, the Stampede station did not run during the winter 02/03. The station was started again in sprin 2003 untill July 1 2003. On this date we rewired the station with two power sources and attempted to run a separate SLM and microphone in order to increase the quality of the audio recordings. The setup created a loud buzz in the recordings making them unusable. After the problem was fixed the microphones were eaten by a bear. The station was then moved to the Lower East Fork Location. The location at Wigand Creek was occupied for a month during June 2003. This location was chosen because it is in the center of the Toklat Basin and it was within the LTEM mini-grid that the bird crew surveyed the same year. The Lower East Fork Location was chosen because it would be accessible during the winter by snowmachine or dog sled and would capture snowmachine traffic.

The data from the Stampede site has been analyzed and is presented in Appendix D. The Upper Wigand Creek Data will be analyzed in 2005. The Lower East Fork Data from 2004 has not been retrieved yet but will be in spring 2005.

PLANS FOR FUTURE STUDY

Because of the failures to collect sufficient summertime data from both the Upper and Lower East Fork River sites both sites will be occupied during the 2005 season. The Lower East Fork site will be accessed in March by either snowmachine and/or dog sled. The Upper East Fork site will be accessed in May when the road is cleared to Sable Pass. The site is easily accessible by skis when the ground is covered in snow, which should be the case if the road crew allows access during road opening. Both sites will be removed at the end of the 2005 summer field season.

Two other sites will be selected for the 2005 summer season. One will be foot accessible and the other will be road accessible. The foot accessible site may be co-located with the bird crew in order to continue the supplementation of bird surveys. The road accessible site may be located in the Kantishna Hills near Caribou Creek. This site has been identified because there is assumed to be a low frequency of overflights and is easily accessible. Site locations are dependent on management needs for the BCMP. All sites will be in place by early June and will be removed at the end of the field season by the first of September.

The preliminary data from the sixteen locations sampled thus far will be useful for comparing current conditions with the desired conditions that will be set in the draft BCMP. Sixteen locations are not enough to produce a statistically robust sample of the entire Park and Preserve. A statistically sound sampling scheme is necessary in order to inventory “credible baseline data” (Murkowski and Gibert, 2004) that will be acceptable to the State of Alaska and other interested parties. Plans for future soundscape studies in Denali include revising the sampling plan from opportunistic to a stratified random sampling plan. A more random sampling plan will make the data more statistically representative of the soundscape characteristics of the entire park. The feasibility of implementing a stratified random sampling scheme depends on sufficient funds. Development of a stratified sampling plan will be done in 2005. This stratified sampling plan will be stratified by acoustical zones, management zones, BCMP management zones, impact zones, and/or access type zones. Communication with management and fellow resource personnel from Denali, the National Soundscape Program Center, and other Parks will be carried out to develop the sampling plan.

Other plans for the 2005 season include development of more automated programs to expand the data analysis capabilities. Two programs are planned for development, one that presents the sound level data averages for each hour of each day for a site during each month at each site, and the second that compiles and computes the one-third octave band data averaged for each hour at each site during each month or defined sampling periods at each site.

Future plans also may include protocol development for CAKN in ’06. If funding is adequate we may possibly develop new sound stations using Solid State HD media field recorders in ’06.

Future plans are dependent on funding for the soundscape program. The soundscape program manager’s position funding has been secured through 2005 from Denali National Park & Preserve base operation funds. To secure funds in 2006 three proposals have been written and put into the PMIS system. One proposal requesting funds from the Regional Block Grant for $82,000 for a two year study in Denali implementing a random stratified sampling plan (PMIS, 110731). Two other proposals request funds from Fee Demo (PMIS 90933) or Franchise Fee (110798) for $242,000, which also implement a random stratified sampling plan over three years. All three proposals request funds starting in 2006.

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APPENDIX A: Funding and Personnel

In 2000, Denali ecologist, Shan Burson, spearheaded Denali soundscape studies by including soundscape inventorying as part of the Southside Development (SSD) resource management proposal (PMIS DENA 24759, NPS, 2000). Project funding included $65,000 for the soundscape component. The goals of the project were to:

1) *Determine and quantify the areas and levels of activity of snowmobiles and aircraft.*

2) *Develop a geographic information system (GIS) database for maps and associated tables that document the frequency, magnitude and duration of noise generated by aircraft and snowmobiles, as well as characterize the natural soundscape, in representative areas of SSD.*

3) *Determine the distance that snowmobile and aircraft sound carries (area of noise impact) under various environmental conditions.*

4) *Provide information needed to minimize noise impact of current and future human activities on park resources and visitors.*

5) *Characterize the baseline soundscape of the region so that long-term changes could be identified.*

Denali was also successful in funding soundscape studies as a small part of a Toklat Basin baseline ecology study (PMIS DENA 24779, NPS, 2001). The sound component was granted $26,000 to accomplish similar goals as listed above for the SSD project. Equipment was purchased in 2001 to build five sound stations. Stations were placed at seven locations during the 2001 summer field season, three locations during the 2002 summer field season, two locations during the 2003 summer field seasons (Figs. 1 and 2).

More recently, in 2004 the soundscape study was funded by three sources, Central Alaska Network Inventory and Monitoring funds, Toklat Basin baseline ecology study (PMIS DENA 24779, NPS, 2001), and Denali Park base funds. The 2004 breakdown is as follows:

- Salary (Oct. 2003 - Dec 2004)
  - $30,145 base funds
  - $12,500 CAKN
- Equipment
  - $12,000 base funds
  - $1,400 Toklat Basin
- OAS/Travel
  - $1,200 base funds
  - $2,000 Toklat Basin

Personnel

2000-2003

- Soundscape Program Manager: Shan Burson

2003-2004

- Soundscape Program Manager: Chad Hults
- Others:
    - Lora May Formatted and Analyzed Toklat Basin Data
        - 46hrs GS-5 ($603.00)
    - Amanda Peacock Formatted Toklat Basin Data
        - 10hrs WG-3 ($200.00)
    - Aja R. UAA Senior Thesis on Denali Soundscape Sampling Plan Stratifying by BCMP zones and impact zones.
        - Volunteer without pay

APPENDIX B: Publications, Presentations, and Trainings

a. Permits
   i. DENA-2001-SCI-0026 "Soundscape Study of Denali National Park and Preserve." Valid April 16, 2001 to December, 31, 2008.

b. Publications
   ii. Central Alaska Network Pre-Scoping Meeting Report: A Brief Summary of Soundscape Studies in the NPS, And Applications to Long-term Monitoring
   iii. 2004 Annual Report (This Report)

c. 2004 Soundscape Presentations (by Chad Hults)
   iv. 02/09/2004 Meeting with AOPA, and other interested parties and presented Soundscape Study design.
   v. 03/27/2004 MIT Sound Presentation with Charlie
   vi. 05/13/2004 Resources Brown Bag PowerPoint
   vii. 05/21/2004 Interpretation Training Sound Presentation
   viii. 05/22/2004 Presented PowerPoint to UAF Resource Management Class
   ix. 06/24/2004 Discovery Camp at Wonder Lake
   x. 07/24/2004 Interview for APRN AK Today
   xi. 08/16/2004 MSLC Poster
   xii. 11/29/2004 CAKN Soundscape Scoping Meeting

d. Trainings (Chad Hults)
   xiii. B3 online refresher
   xiv. Helicopter Manager Training
   xv. Carhart Wilderness Workshop

APPENDIX C: Equipment Lists

Station Location	Dates	Equipment List (see below)
2001		
DUNK		Akw
TOKL		Aks
TOKO		Aks
SAVG		Aks
TEKP		Aks
WOND		Aks
7MIL		Aks
2002		
BASE		Aks
RUTH		Aks
PIKA		Aks
2003		
STAM		Akw
UPWC		Bks
2004		
FROG		Cks
LEFK	10/04-	Dkw
USVG		Cp
UEFK	6/04-8/30/04	Cp
	8/30/04-9/04	Dp

Equipment List A (Audio through SLM using computer audio)

Aks = Knaack Box 2032 Summer

#/Station	Item
1	*Kycotera* 85W Solar Panel (PV)
1	*Kycotera* 35W Solar Panel (PV)
1	Angle Aluminum Solar Panel Frames
2	Batteries 100Ah Gel Cell
1	Batteries 35Ah Gel Cell
1	10A *SunSaver 10* Solar Controller
1	Laptop (*Pannasonic Toughbook 45*)
1	1” Galvanized Electrical Conduit (Microphone Stand)
1	*Pelican Case* 1520
1	*Kanguru Solutions* USB Powered 40Gb External Hard Drive
1	Lock *MasterLock*

Larson-Davis SLM:

- 1 *Larson Davis 824* SLM
- 1 *Larson Davis PRM 902* Type 1 mic Pre-amp
- 1 *G.R.A.S. 40AE* Type 1 microphone
- 1 *Larson Davis* Microphone Cable 25'
- 1 *Larson Davis* Stereo Miniplug Audio Adapter
- 1 *Larson Davis* Environmental Kit (mic tube, foam windscreen, bird spike)
- 1 *Larson Davis* SLM to Computer Serial Cable
- 1 Desiccants

Akw = Knaack Box 2048 Winter

#/Station Item

- 4 *Kycotera* 85W Solar Panels (PV)
- 1 *Kycotera* 35W Solar Panels (PV)
- 3 Angle Aluminum Solar Panel Frames
- 4 Batteries 100Ah Gel Cell
- 1 Batteries 35Ah Gel Cell
- 1 30A *Trace Engineering* Solar Controller
- 1 Laptop (*Pannasonic Toughbook 45*)
- 1 1” Galvanized Electrical Conduit (Microphone Stand)
- 1 *Pelican Case* 1520
- 1 *Kanguru Solutions* USB Powered 40Gb External Hard Drive
- 1 Lock *MasterLock*

Larson-Davis SLM:

- 1 *Larson Davis 824* SLM
- 1 *Larson Davis PRM 902* Type 1 mic Pre-amp
- 1 *G.R.A.S. 40AE* Type 1 microphone
- 1 *Larson Davis* Microphone Cable 25'
- 1 *Larson Davis* Stereo Miniplug Audio Adapter
- 1 *Larson Davis* Environmental Kit (mic tube, foam windscreen, bird spike)
- 1 *Larson Davis* SLM to Computer Serial Cable
- 1 Desiccants

Equipment List B (Audio through a separate SLM using computer audio and separate power sources)

Bks = Knaack Box 2032 Summer

#/Station Item

- 1 *Kycotera* 85W Solar Panel (PV)
- 1 *Kycotera* 35W Solar Panel (PV)
- 1 Angle Aluminum Solar Panel Frames
- 2 Batteries 100Ah Gel Cell
- 1 Batteries 35Ah Gel Cell

- 1 10A *SunSaver 10* Solar Controller
- 1 Laptop (*Pannasonic Toughbook 45*)
- 1 *Bogen* Tripods (Microphone Stands)
- 6 Microphone Stand Anchor Screws
- 1 *Pelican Case* 1520
- 1 *Kanguru Solutions* USB Powered 40Gb External Hard Drive
- 1 Lock *MasterLock*

Larson-Davis SLM:

- 1 *Larson Davis 824* SLM
- 1 *Larson Davis PRM 902* Type 1 mic Pre-amp
- 1 *G.R.A.S. 40AE* Type 1 microphone
- 1 *Larson Davis* Microphone Cable 25'
- 1 *Larson Davis* Environmental Kit (mic tube, foam windscreen, bird spike)
- 1 *Larson Davis* SLM to Computer Serial Cable
- 1 Desiccants

Audibility Recordings:

- 1 *Larson Davis 824* SLM
- 1 *Larson Davis PRM 902* Type 1 mic Pre-amp
- 1 *G.R.A.S. 40AE* Type 1 microphone
- 1 *Larson Davis* Microphone Cable 25'
- 1 *Larson Davis* Stereo Miniplug Audio Adapter
- 1 *Larson Davis* Environmental Kit (mic tube, foam windscreen, bird spike)
- 1 Desiccants

Equipment List C (Audio through a *Sennheiser* mic and *MoblilePre* soundcard)

Cks = Knaack Box 2032 Summer

#/Station Item

- 1 *Kycotera* 85W Solar Panels (PV)
- 1 *Kycotera* 35W Solar Panels (PV)
- 1 Angle Aluminum Solar Panel Frames
- 2 Batteries 100Ah Gel Cell
- 1 10A *SunSaver 10* Solar Controller
- 1 Laptop (*Pannasonic Toughbook 45*)
- 1 USB 2 PCMCIA Adaptor Card
- 1 Duct Seal for microphone holders
- 2 *Bogen* Tripods (Microphone Stands)
- 6 Microphone Stand Anchor Screws
- 1 *Pelican Case* 1520
- 1 *Kanguru Solutions* USB Powered 40Gb External Hard Drive
- 1 Lock *MasterLock*

Larson-Davis SLM:

- 1 *Larson Davis 824* SLM
- 1 *Larson Davis PRM 902* Type 1 mic Pre-amp
- 1 *G.R.A.S. 40AE* Type 1 microphone
- 1 *Larson Davis* Microphone Cable 25'
- 1 *Larson Davis* Environmental Kit (mic tube, foam windscreen, bird spike)
- 1 *Rycote Windjammer* "Fuzzy" Windscreen
- 1 *Larson Davis* SLM to Computer Serial Cable
- 1 Desiccants

Audibility Recordings:

- 1 External *MobilePre* Soundcard
- 1 *Sennheiser K6P* Power Module
- 1 *Sennheiser ME62* Microphone Capsule
- 1 XLR Cable (25')
- 1 Home Rigged Environmental Kit (PVC mic tube, cloths hanger bird spike)
- 1 *Larson Davis* Foam Windscreen
- 1 *Rycote Windjammer* "Fuzzy" Windscreen

Ckw = Knaack Box 2048 Winter

#/Station Item

- 4 *Kycotera* 85W Solar Panels (PV)
- 1 *Kycotera* 35W Solar Panels (PV)
- 3 Angle Aluminum Solar Panel Frames
- 4 Batteries 100Ah Gel Cell
- 1 Batteries 35Ah Gel Cell
- 1 30A *Trace Engineering* Solar Controller
- 1 Laptop (*Pannasonic Toughbook 45*)
- 1 USB 2 PCMCIA Adaptor Card
- 1 Duct Seal for microphone holders
- 2 *Bogen* Tripods (Microphone Stands)
- 6 Microphone Stand Anchor Screws
- 1 *Pelican Case* 1520
- 1 *Kanguru Solutions* USB Powered 40Gb External Hard Drive
- 1 Lock *MasterLock*

Larson-Davis SLM:

- 1 *Larson Davis 824* SLM
- 1 *Larson Davis PRM 902* Type 1 mic Pre-amp
- 1 *G.R.A.S. 40AE* Type 1 microphone
- 1 *Larson Davis* Microphone Cable 25'

- 1 *Larson Davis* Environmental Kit (mic tube, foam windscreen, bird spike)
- 1 *Rycote Windjammer* "Fuzzy" Windscreen
- 1 *Larson Davis* SLM to Computer Serial Cable
- 1 Desiccants

Audibility Recordings:

- 1 External *MobilePre* Soundcard
- 1 *Sennheiser K6P* Power Module
- 1 *Sennheiser ME62* Microphone Capsule
- 1 XLR Cable (25')
- 1 Home Rigged Environmental Kit (PVC mic tube, cloths hanger bird spike)
- 1 *Larson Davis* Foam Windscreen
- 1 *Rycote Windjammer* "Fuzzy" Windscreen

Cp = Pelican Case 1520

#/Station Item

- 8 *Solarex MSX Lite* 20W Solar Panels (PV)
- 16 Tent Stakes for Solar Panels
- 16 Aluminum Rods to raise top edge of Solar Panels (1/4" x 18")
- 4 Batteries 35Ah
- 1 10A *Sun Saver* 10 Solar Controller
- 1 Laptop (*Pannasonic Toughbook 45*)
- 1 USB 2 PCMCIA Adaptor Card
- 1 Duct Seal for microphone holders
- 2 *Bogen 3372* Light Stands (Microphone Stands)
- 6 Microphone Stand Mesh bags for Weight
- 1 *Pelican Case* 1520
- 1 *Kanguru Solutions* USB Powered 40Gb External Hard Drive
- 1 Lock (P-1 from B&U)

Larson-Davis SLM:

- 1 *Larson Davis 824* SLM
- 1 *Larson Davis PRM 902* Type 1 mic Pre-amp
- 1 *G.R.A.S. 40AE* Type 1 microphone
- 1 *Larson Davis* Microphone Cable 25'
- 1 *Larson Davis* Environmental Kit (mic tube, foam windscreen, bird spike)
- 1 *Rycote Windjammer* "Fuzzy" Windscreen
- 1 *Larson Davis* SLM to Computer Serial Cable
- 1 Desiccants

Audibility Recordings:

- 1 External *MobilePre* Soundcard
- 1 *Sennheiser K6P* Power Module
- 1 *Sennheiser ME62* Microphone Capsule
- 1 XLR Cable (25')
- 1 Home Rigged Environmental Kit (PVC mic tube, cloths hanger bird spike)
- 1 *Larson Davis* Foam Windscreen
- 1 *Rycote Windjammer* "Fuzzy" Windscreen

Equipment List D (Audio Through a *G.R.A.S.* Mic and *MobilePre* Soundcard)

Dkw = Knaack Box 2048 Winter

#/Station Item

- 5 *Kycotera* 85W Solar Panels (PV)
- 3 *Kycotera* 35W Solar Panels (PV)
- 3 Angle Aluminum Solar Panel Frames
- 5 Batteries 100Ah Gel Cell
- 1 30A *Trace Engineering* Solar Controller
- 1 Laptop (*Pannasonic Toughbook 45*)
- 1 USB 2 PCMCIA Adaptor Card
- 1 Duct Seal for microphone holders
- 2 *Bogen* Tripods (Microphone Stands)
- 6 Microphone Stand Anchor Screws
- 1 *Pelican Case* 1520
- 1 *Kanguru Solutions* USB Powered 80Gb External Hard Drive
- 1 Lock *MasterLock*

Larson-Davis SLM:

- 1 *Larson Davis 824* SLM
- 1 *Larson Davis PRM 902* Type 1 mic Pre-amp
- 1 *G.R.A.S. 40AE* Type 1 microphone
- 1 *Larson Davis* Microphone Cable 25'
- 1 *Larson Davis* Environmental Kit (mic tube, foam windscreen, bird spike)
- 1 *Rycote Windjammer* "Fuzzy" Windscreen
- 1 *Larson Davis* SLM to Computer Serial Cable
- 1 Desiccants

Audibility Recordings:

- 1 External *MobilePre* Soundcard
- 1 *G.R.A.S. 26CA* Pre-amp
- 1 *G.R.A.S. 40AE* Microphone
- 1 BNC Cable *Belden* (25')
- 1 BNC Female-XLR female connector

- 1 Home Rigged Environmental Kit (PVC mic tube, cloths hanger bird spike)
- 1 *Larson Davis* Foam Windscreen
- 1 *Rycote Windjammer* “Fuzzy” Windscreen

Dp = Pelican Case 1520

#/Station Item

- 8 *Solarex MSX Lite* 20W Solar Panels (PV)
- 16 Tent Stakes for Solar Panels
- 16 Aluminum Rods to raise top edge of Solar Panels (1/4" x 18")
- 4 Batteries 35Ah
- 1 10A *Sun Saver* 10 Solar Controller
- 1 Laptop (*Pannasonic Toughbook 45*)
- 1 USB 2 PCMCIA Adaptor Card
- 1 Duct Seal for microphone holders
- 2 *Bogen 3372* Light Stands (Microphone Stands)
- 6 Microphone Stand Mesh bags for Weight
- 1 *Pelican Case* 1520
- 1 *Kanguru Solutions* USB Powered 40Gb External Hard Drive
- 1 Lock (P-1 from B&U)

Larson-Davis SLM:

- 1 *Larson Davis 824* SLM
- 1 *Larson Davis PRM 902* Type 1 mic Pre-amp
- 1 *G.R.A.S. 40AE* Type 1 microphone
- 1 *Larson Davis* Microphone Cable 25'
- 1 *Larson Davis* Environmental Kit (mic tube, foam windscreen, bird spike)
- 1 *Rycote Windjammer* “Fuzzy” Windscreen
- 1 *Larson Davis* SLM to Computer Serial Cable
- 1 Desiccants

Audibility Recordings:

- 1 External *MobilePre* Soundcard
- 1 *G.R.A.S. 26CA* Pre-amp
- 1 *G.R.A.S. 40AE* Microphone
- 1 BNC Cable *Belden* (25')
- 1 BNC Female-XLR female connector
- 1 Home Rigged Environmental Kit (PVC mic tube, bird spike)
- 1 *Larson Davis* Foam Windscreen
- 1 *Rycote Windjammer* “Fuzzy” Windscreen

APPENDIX D: Sampling Location Descriptions and Data Analyzed

A summary of the data analyzed as of December 2004 are presented on the following pages. Each section begins with a location description cover sheet. Following the description cover sheet are selected charts that summarize the data analyzed thus far from each location. Each data compilation summary completed for each location contain ten charts; one chart showing the sum of all sounds identified, four charts characterizing the natural soundscape, based exclusively on audibility, and five charts relating to backcountry management planning, which show the levels of motorized impacts. The charts for each compilation are as follows:

General Soundscape Characterization (Using Audibility Only)

1. Daily Abundances of Human-Generated Sounds, Geophony, and Biophony.

Natural Soundscape Characterization (Using Audibility Only):

2. Daily Abundances of Geophony Types.
3. Daily Abundances of Biophony Types.
4. Daily Abundances of Bird-Calls.
5. Daily Abundances of Insect Sounds.

Levels of Motorized Impacts (Using Sound Levels and Audibility):

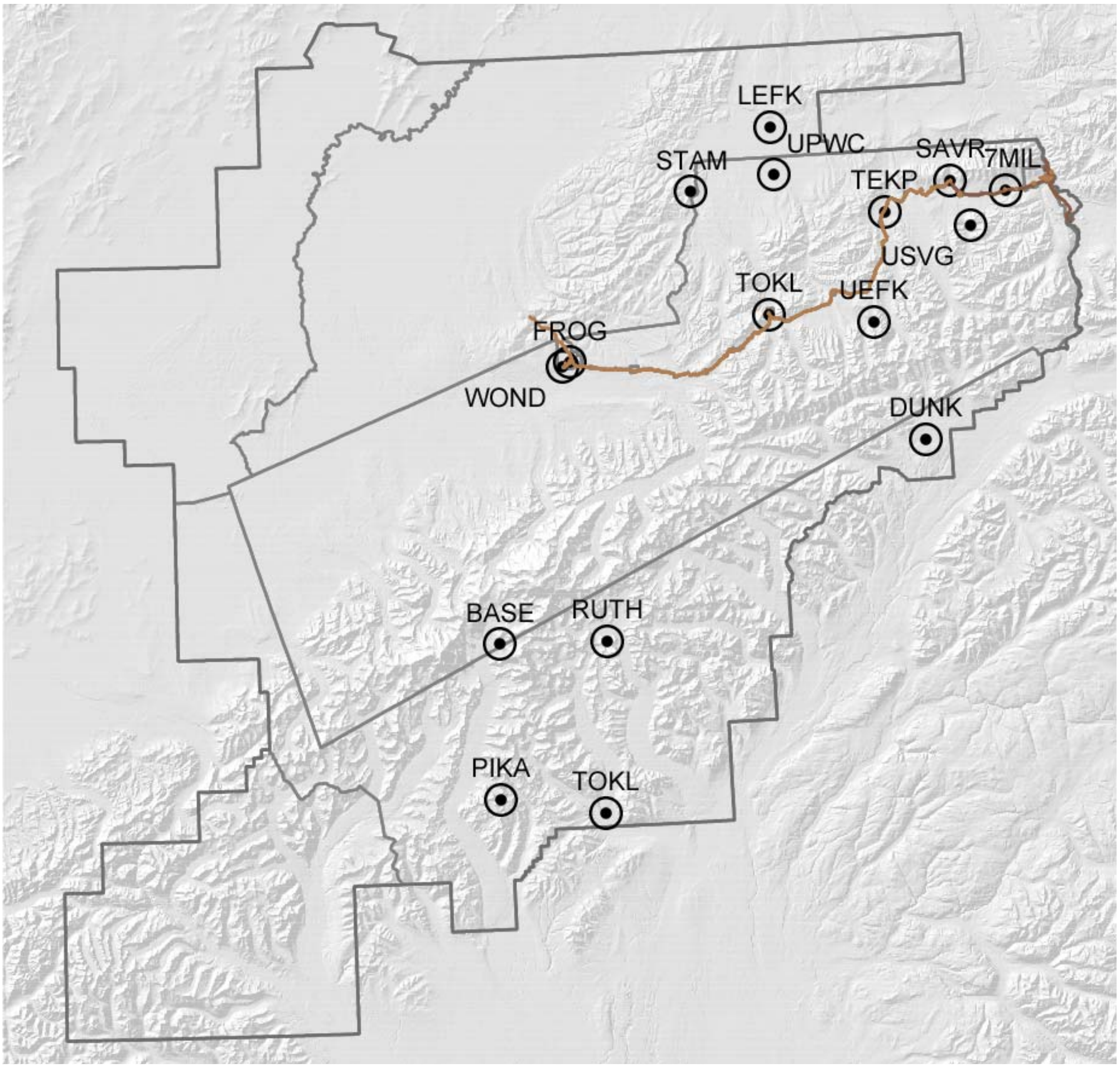
6. Daily Abundances of Motorized Sounds.
7. Sum of Motorize Sound Levels Per Hour
8. Percent Motorize Sounds Audible Per Hour
9. Number of Motorized Sounds Greater than Natural Ambient Levels
10. Motorized Sound Levels

Explanation of the Calculations for Charts 9 and 10:

9. The number of motorized sounds greater than natural ambient levels is found by calculating the difference between two values; natural ambient, and sound level of each motorized sound identified.
    a. Natural ambient: The natural ambient level is calculated for each hour of each day by first calculating the % time motorized sounds are audible for each hour (% motor/hr). The natural ambient for each hour is calculated by removing the top motorized percentage (% motor/hour) from all of the sound levels for the hour. The median is then taken (L50), which is an approximation of the natural ambient level. In this calculation there is the assumption that the majority of motorized sounds are greater than natural ambient. Preliminary tests done by Skip Ambrose from the National Park Service Soundscape Program Center (personal communication) have shown that this calculation is consistently within 1dB of the actual natural ambient

level calculated by removing all motorized sound levels for an hour identified by a continuous recording for the hour. The motorized sound level is calculated as in chart ten as explained in #10 below. A motorized sound is considered greater than the natural ambient level if the overall sound sound level during the time a motorized sound is audible, as calculated in #10 below, is greater than 3dBA than the natural ambient level for that hour.

10. The motorized sound levels are calculated by first identifying which of the 288 five second audio segments, recorded throughout the day, contain motorized sounds. The time for each segment is then identified. Then the median of the ten seconds of sound levels nearest each audio clip is calculated. The median of these ten seconds is assumed to be representative of the motorized sound level plus the natural ambient level.


LEFK
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